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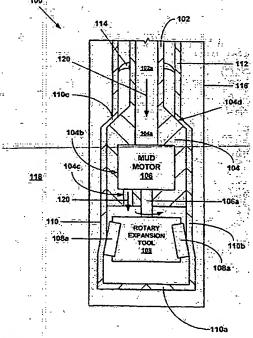
(52) UK CL (Edition X.): NOT CLASSIFIED

(56) Documents Cited: EP 1505251 A3

US 3785193 A

(58) Field of Search: INT CL B21D, E21B Other: EPODOC, WPI

- (54) Abstract Title: Radially expanding a wellbore casing using an expansion mandrel and a rotary expansion cone
- (57) A method of radially expanding and plastically deforming a tubular member 112 involves applying forces to a continuous circumferential portion of the interior and further expanding the tubular by applying forces to discreet portions of the tubular. The expander tools can be an expansion cone 104 and roller expanders 108: A hydroforning expansion tool can also be used.



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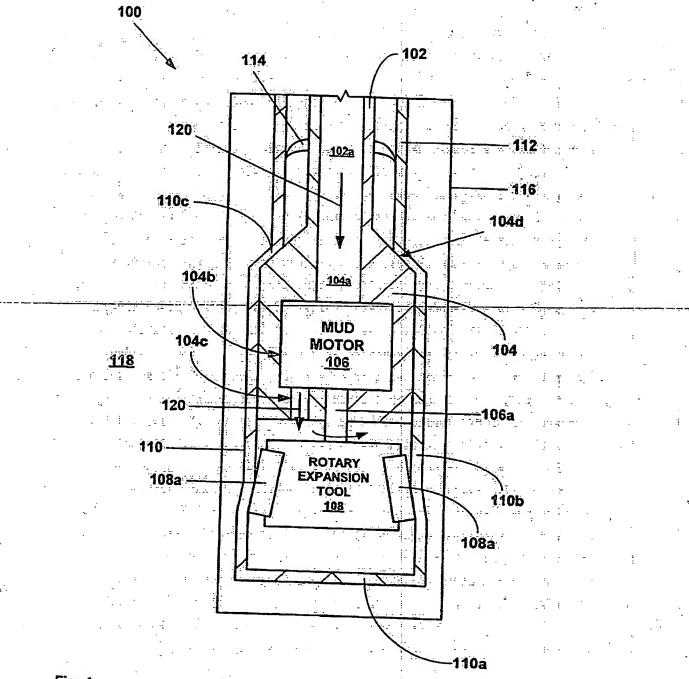


Fig. 1

DSING AN EXPANSION MANDREL AND A ROTARY EXPANSION TOOL

Cross Reference To Related Applications

The present application claims the benefit of the filing date of U.S. provisional patent application serial no. 60/454,896; attorney docket no. 25791.236, filed on March 14, 2003, the disclosure of which is incorporated herein by reference.

The present application is related to the following: (1) U.S. Patent Number

on Isise in patent number 6,604,75, which was filed as application serial no. no bell ,855,801,00 noising isnoisivon mon viring selicition 69,100 noising selection Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed confination-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. application serial no. 09/981,916, attorney docket no. 25791,18, filed on 10/18/01 as a priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent no. :09/588,946; attorney docket no. 25791.17.02; filed on 6/7/2000, which claims 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial on 2/24/2000, which claims priority from provisional application 60/121,907, filed on filed as patent application serial no: 09/511,941, attorney docket no. 25791:16.02, filed application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was docket no. 25791-12.02, filed on 2/24/2000, which claims priority from provisional number 6,568,471, which was filed as patent application serial no: 09/512,895, attomey claims priority from provisional application 60/124,042, filled on 3/11/99, (7) U.S. patent senal no. 09/523,468, attorney docket no. 25791,11.02, filed on 3/10/2000, which from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent application no: 10/169,434, attorney docket no. 25791,10.04, filed on 7/1/02, which claims priority provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial attomey docket number 25791.9.02, filed on 11/15/99, which claims priority from 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. serial no. 09/502,350, attomey docket no. 25791.8:02, filed on 2/10/2000, which claims from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application 09/510,913, attomey docket no. 25791.7.02, filed on 2/23/2000, which claims priority application 60/11/293, filed on 12/7/98, (2) U.S. patent application senal no. docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional 6.497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attomey

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09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02; which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791:34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419; filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39; filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791,44:02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45:07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791-45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from

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which claims priority from U.S. provisional patent application serial no. 60/326,886, (3Z) PCT Application US02/29856, attorney docket no: 25791.60.02, filed on 9/19/02, application serial no. 60/313,453, attomey docket no. 25791:59, filed on 8/20/2001, 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent attorney docket no. 25791.58, (36) PCT-Application US02/24399, attorney docket no. 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, 12/7/98 (35) PCT Application US02/25608; attorney docket no. 25791.58.02, filed on on 12/3/1999, which claims priority from provisional application 60/111,293, filed on as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed 25/197, 3s as a divisional application of U.S. Patent Number 6,497,289, which as filed 52 patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. which claims priority from provisional application 60/1/1,593; filed on 12/7/98, (34) U.S. Application serial no: 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application 12/3/1999, which claims priority from provisional application 60/111,293, filed on Patent Application serial not 09/454,139; attorney docket no. \$5791.03.02; filed on a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. application serial number 09/850,093, filed on 5/701, attorney docket no. 25791.55, as docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent U.S. provisional patent application serial no: 60/452,303, filed on 3/5/03, attomey application serial no. 60/259,486, attomey docket no. 25791.52, filed on 1/3/2001, (31) attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent filed on 1/17/2001, (30) U.S. patent application senal no. 10/465,831, filed on 6/13/03, 01 from provisional patent application senal no. 60/262,434; attorney docket no. 25791,51, 10/465,835, filed on 6/13/03; attorney docket no: 25791,51,06, which claims priority afformey docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. which claims priority from U.S. provisional patent application serial no. 60/270,007, (28) PGT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02; application senal no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, 25791.48.06, which claims priority from provisional patent attorney docket no. on 9/18/2000, (SZ) U.S. patent application serial no: 10/406,648, filed on 3/31/03, provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed

attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket-no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99; (40) U.S. patent application serial no. 09/962,470; filed on 9/25/01; attorney docket no. .25791.63; which is a divisional of U.S. patent application serial no 09/523,468, attorney docket no 25791.11.02, filed on 3/10/2000, which claims priority from provisional application: 60/124,042; filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on .9/25/01; attorney docket no. .25791.64; which is a divisional of U.S. patent application serial no 09/523,468, attorney docket no 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no 09/962,467, filed on 9/25/01, attorney docket no. - 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468. attorney docket no. 25791:11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042; filed on 3/11/99; (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of 20 U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317/985, attorney docket no. 25791/67, filed on 9/6/2001, and U.S. provisional patent application serial no 60/318,386, attorney docket no 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674 attorney docket no. 25791.68, filed on 12/27/2001 (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338; attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on-11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70; filed on 12/10/01, which is a continuation application of

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2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application senal no. 10/078,922, attorney docket no. 25791.80, filed on which claims priority from provisional application 60/121,841; filed on 2/26/99, (55) U.S. application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which is a divisional of U.S. patent number 6,568,471, which was filed as patent 30 application serial no. 10/078,928, attorney docket no. - 25791,79, filed on 2/20/02, priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims divisional of U.S. patent number 6,568,471, which was filed as patent application serial 25 serial no. 10/076,659, attorney docket no. 25791;78, filed on 2/15/02, which is a from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application * 09/512,895; attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority U.S. patent number 6,568,471, which was filed as patent application senal no. 10/076,661, attorney docket no 25791777 filled on 2/15/02; which is a divisional of 20 application 60/121,841; filed on 2/26/99, (52) U.S. patent application serial no: docket no. 25791:12:02, filed on 2/24/2000, which claims priority from provisional rumber 6,568,471 which was filed as patent application serial no. 09/512,895, attorney attomey docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent 60/121,841; filed on 2/26/99, (51) U.S. patent application senal no. 10/076,660, 15 25791.12.02, filed on 2/24/2000, which claims priority from provisional application . which was lijed as bateut abblication senal no 09/6/12/892, attomey docket no LINE SECTION OF TRANSPORT IS A divisional of U.S. patent number 6,568,471. 2/26/99, (50) U.S. patent application senal no. 10/074,244, attorney docket no. 2/24/2000, which claims priority from provisional application 60/121,841, filed on 10 patent application senal no. 09/512,895, attomey docket no. 25791.12.02, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on application senal no. 60/357,372, attorney docket no. 25791 71, filed on 2/15/02, (49) attomey docket no. 25791-71.02, which claims priority from U.S. provisional patent 5 - 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, number 25791.9.02, filed on 11/15/99, which claims priority from provisional application which was filed as U.S. Patent Application serial number 09/440,338, attorney docket on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed

patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, 5 which was filed as patent application serial no. 09/512,895, attorney docket no. 25791 12:02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no: 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. =10/079,276 = attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791,17.02, filed on 6/7/2000, which claims priority from provisional application: 60/137,998; filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791 12:02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02; which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no: 25791.89.02, which claims priority from U.S. provisional patent application serial

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patent application senal no. 60/372,632, attorney docket no. 25791.101, filed on 3/28/03; attomey docket no.: 25791.101.02; which claims priority from U.S. provisional - application 60/11/1,293, filed on 12/7/98, (74) PCT application US 03/10/144, filed on docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional 30 : 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791,100, filed on 7/19/02, which is a continuation of U.S. Patent Number 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney no. 25791:17.02, filed on 6/7/2000, which claims priority from provisional application 6;557,640, which was filed as patent application serial no. 09/588,946, attorney docket 25 -- docket no. :25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 60/137,998, filed on 6/7/99, (72) U.S. patent application senal no. 10/261,925, attorney no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 6.557,640, which was filed as patent application serial no. 09/588,946, attorney docket docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 20 = 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attomey no. 25791 17.02, Tilled on 6/7/2000, which claims priority from provisional application 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 25791.95, filed on 3/13/02, (70) U.S. patent application serial no 10/26/1,927, attorney . from 14:5≈ provisional≟patent application; serial; no. − 60/363,829,⊵atiomey docket no. - US-03/04837, filed on-2/29/03; attorney docket no. 25791:95:02; which claims priority 60/159,033, attorney docket no 25791.37, filed on 10/12/1999, (69) PCT application 25791.37.02, which claims priority from provisional patent application senal no. patent application senal no. 209/679,906, filed on 10/5/00; attomey docket no. 10/331,718, afforney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. - docket no -25791.93, filed on 4/12/02, (68) U.S. patent application serial no. claims priority from U.S. provisional patent application serial no. 60/372,048, attorney PCT application US 03/06544, filed on 3/4/03; attorney docket no. 25791:93.02, which application serial no. .60/346,309; attorney docket no. 25791.92; filed on 1/7/02; (67) 5 attorney docket no: 25791.92.02, which claims priority from U.S. provisional patent 25791 90; filed on 6/26/02; (66) PCT application US 02/39418; filed on 12/10/02; from U.S. provisional patent application senal no. 60/391,703, attorney docket no. US 03/15020, filled on 5/12/03, attomey docket no. 25791:90:02; which claims priority no. 60/383,917, attomey docket no. 25791.89, filed on 5/29/02, (65) PCT application

4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US-03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791,104, filed on 5/6/02, (77) 5 PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791:106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791,107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486 attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US-03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 15 25791.110; filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority-from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no 60/412,487, attorney docket no. ,25791-112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 20 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356; attorney docket no. 25791,115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653; attorney docket no. 25791 118, filed on 9/20/02, (87) U.S. provisional patent application serial no:::60/405,610, attorney docket no: 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no: 25791.120, filed on 8/23/02, (89) U.S. provisional patent application senal no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application PCT/US03/24779; filed on 8/8/03; attorney docket no. 25791.125.02; which claims

which is a continuation of U.S. patent application serial no. 09/523,468, attorney docket application senal no. 10/421,682, attorney docket no. 25791,256; filed on 4/23/03, 60/453,678, attorney docket no. 25791.253; filed on 3/11/03, (110) U.S. patent 25791.261, filed on 3/17/03, (109) U.S. provisional patent application serial no. (108). U.S. provisional patent application serial no. 60/455,124, attorney docket no. patent application senal no. 60/451,152, attorney docket no. 25791,239, filed on 3/9/03, 60/450,504, attorney docket no. 25791.238, filed on 2/26/03, (107) U.S. provisional no. 25791.236, filed on-3/14/03, (106) 'S: provisional patent application senal no. 4/18/03, (105) U.S. provisional patent application senal no. 60/454,896, attomey docket patent application senal no 60/418,687, attorney docket no. 25791.228, filed on 52 no: 60/442,938, attomey docket no: 25791.225, filed on 1/27/03, (104) U.S. provisional docket no: 25791:213, filed on 1/27/03, (103) U.S. provisional patent application senal 12/23/02, (102) U.S. provisional patent application senal no. 60/442,942, attorney batent application senal no. 60/436,106, attorney docket no. 25791,200, filed on 20 60/462;750, attorney docket no. 25791.193, filed on 4/14/03; (101) U.S. provisional no 25791 186; filed on 4/9/03; (100) U.S. provisional patent application serial no. 2/18/03, (99) U.S. provisional patent application serial no. 60/461,539, attorney docket patent application serial no. 60/448,526, attorney docket no. 25791-185, filed on no. 60/431, 184, attorney docket no. 25791.157, filed on. 12/5/02, (98) U.S. provisional 15. application 60/11, 116d on 2/11/99, (97) U.S. provisional patent application senal docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional 7122/03, which is a divisional of U.S. patent application senal no.09/502,350, attomey patent application senal no. 10/624,842, attomey docket no. 25791.151, filed on Which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. application serial no: 09/588;946, attorney docket no: 25791.17.02, filed on 6/7/2000, which is continuation of U.S. patent number 6,557,640, which was filed as patent application senal no. 10/382,325, attorney docket no. 25791-145, filed on 3/5/03, 60/412,371, attorney docket no. 25791,129, filed on 9/20/02, (95) U.S. patent no. 25791-128, filed on 9/20/02, (94). S. provisional patent application serial no. 9/20/02; (93) U.S. provisional patent application serial no. 60/412,187; attorney docket patent application senal no. 60/412,196, attorney docket no. 25791.127, filed on 60/423,363, attorney docket no. 25791,126, filed on 12/10/02, (92) U.S. provisional no. 25791,125, filed on 8/30/02, (91). U.S. provisional patent application serial no. priority from U.S. provisional patent application serial no. 60/407,442, attorney docket

no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (111) U.S. provisional patent application serial no. 60/457,965, attorney docket no. 25791.260, filed on 3/27/03, (112) U.S. provisional patent application serial no. 60/455,718, attorney docket no. 25791.262, filed on 3/18/03; (113) U.S. patent number 6,550,821, which was filed as patent application serial no. 09/811,734, filed on 3/19/01, (114) U.S. patent application serial no. 10/436,467, attorney docket no. 25791,268, filed on 5/12/03, which is a continuation of U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from 10 provisional application 60/131,106, filed on 4/26/99, (115) U.S. provisional patent application serial no. 60/459,776, attorney docket no. 25791.270, filed on 4/2/03, (116) U.S. provisional patent application serial no. (60/461,094, attorney docket no. 25791.272, filed on 4/8/03; (117) U.S. provisional patent application serial no. 60/461,038, attorney docket no. 25791.273, filed on 4/7/03, (118) U.S. provisional 15 patent application serial no. 60/463,586, attorney docket no. 25791.277, filed on 4/17/03, (119) U.S. provisional patent application serial no. 60/472,240, attorney docket no. 25791.286, filed on 5/20/03, (120) U.S. patent application serial no. 10/619,285, attorney docket no. 25791 292, filed on 7/14/03, which is a continuation-in-part of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791,69, filed on 20 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (121) U.S. utility patent application serial no. 10/418,688, attorney docket no. 25791:257, which was filed on 4/18/03, as a division of U.S. utility 25 patent application serial no. 09/523,468; attorney docket no. 25791.11.02; filed on 3/10/2000; which claims priority from provisional application 60/124,042, filed on 3/11/99, (122) PCT patent application senal no _____, attorney docket no. 25791.238.02, filed on (123) PCT patent application serial no. attorney docket no. 25791.253.02, filed on _____, and (124) PCT patent application serial no. _____, attorney docket no. 25791.40.02; filed on the disclosures of which are incorporated herein by reference: Background of the Invention This invention relates generally to oil and gas exploration, and in particular to

forming and repairing wellbore casings to facilitate oil and gas exploration.

diameters drilled in the course of the well, and the large volume of cuttings drilled and cement: hardening, required: equipment changes due do large variations in hole Moreover, increased dilling rig time is involved due to required cement pumping, equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. a large borehole diameter involves increased costs due to heavy casing handling s relatively large borehole diameter is required at the upper part of the wellbore. Such seal the casings from the borehole wall. As a consequence of this nested arrangement annuli are provided between the cutter surfaces of the casings and the borehole wall to nested arrangement with casing diameters decreasing in downward direction. Cement smaller diameter than the casing of the upper interval. Thus, the casings are in a interval. As a consequence of this procedure; the casing of the lower interval is of borehole interval is lowered through a previously installed casing of an upper borehole The borehole is drilled in intervals whereby a casing which is to be installed in a lower of drilling fluid the formation or fluid from the formation of the borehole. the borehole to prevent collapse of the borehole wall and to prevent undesired outflow Conventionally, when a wellbore is created, a number of casings are installed in

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repaining wellbore casings.

Summary of the Invention

According to one aspect of the present invention, an apparatus for radially expanding and plastically deforming a fubular member is provided that includes a tubular support member defining a first passage, a tubular expansion cone defining a second passage coupled to the tubular expansion cone comprising an inlet, and a rotary expansion device coupled to the output shaft of the fluid driven motor. The first passage is operably coupled to the output shaft of the fluid driven motor.

The first passage is operably coupled to the inlet of the driven motor.

According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming a tubular member, and a second expansion device for controllably straining the tubular member, and a second expansion device coupled to the first expansion device coupled to the first expansion device controllably stressing the tubular member.

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According to another aspect of the present invention, a method of radially

expanding and plastically deforming a tubular member is provided that includes controllably straining the tubular member, and then controllably stressing the tubular member.

According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming a tubular member is provided that includes means for controllably straining the tubular member, and means for controllably stressing the tubular member after controllably straining the tubular member.

According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming a tubular member is provided that includes a first expansion device for radially expanding the tubular member, and a second expansion device coupled to the first expansion device for further radially expanding the tubular member.

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According to another aspect of the present invention, a method of radially expanding and plastically deforming a tubular member is provided that includes radially expanding a portion of the tubular member, and then further radially expanding the portion of the tubular member.

According to another aspect of the present invention, a system for radially expanding and plastically deforming a tubular member is provided that includes means for radially expanding a portion of the tubular member, and means for then further radially expanding the portion of the tubular member.

According to another aspect of the present invention, a method of radially expanding and plastically deforming a tubular member is provided that includes controllably stressing the tubular member; and then controllably straining the tubular member.

According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming a tubular member is provided that includes means for controllably stressing the tubular member, and means for controllably straining the tubular member after controllably stressing the tubular member.

Brief Description of the Drawings

Fig. 1 is a fragmentary cross sectional illustration of an exemplary embodiment of an apparatus for radially expanding a tubular member.

Detailed Description of the Illustrative Embodiments

Referring to Fig. 1, an exemplary embodiment of an apparatus 100 for radially expanding a tubular member includes a tubular support member 102 that defines a

passage 102a. An end of an expansion mandrel 104 that defines a passage 104a, a chamber 104b, and a passage 104c is coupled to an end of the tubular support member 102 that includes a tapered outer surface 104d.

A conventional mud motor 106 is positioned within the chamber 104b of the mandrel 104 that includes an rotable output shaft 106a that extends out of the mandrel. The inlet of the mud motor 106 is fluidictly coupled to the passage 104a of the mandrel, and the outlet of the mud motor is fluidictly coupled to the passage 104c of the mandrel, and the outlet of the mud motor 106 may be operated to rotate the shaft 106a upon pumping fluidic materials into and through the mud motor. A conventional rotary expansion tool 108 is coupled to an end of the shaft 106a that may be any number of conventional commercially available rotary expansion devices such as, for example, the rotary expansion devices commercially available from Such that any number of conventional connectional devices commercially available from 5457;532 and/or WO 02/081863 A1, the disclosures of which are incorporated herein by reference. In an exemplary embodiment, the rotary expansion tool 108 includes one or more circumferentially and/or axially spaced apart roller expansion elements 108a, or more circumferentially and/or axially spaced apart roller expansion elements 108a.

The mandrel 104, the mud motor 106, and the rotary expansion tool 108 are housed within a tubular launcher assembly 110 that includes a shoe 110a, a tubular section 110b, and a tapered tubular section 110b of the tubular section 110b of the tubular launcher assembly 110 mates with the mandrel 104 and the rotary expansion tool 108. An end of an expandable tubular 112 is coupled to the tapered tubular section 110c of the launcher assembly 110. In an exemplary embodiment, one or more cup seals 114 are coupled to the extenor of the tubular support 102 for sealingly engaging the interior surface of the expandable tubular member 112.

In an exemplary embodiment, the apparatus is initially positioned within a borehole 116 that traverses a subtemanean formation 118. Fluidic materials 120 are then conveyed into and through the mud motor 106 and out of the mandrel 104 through the passage 104c. As a result, the mud motor 106 is operated to thereby rotate the shaft 106s and the rotary expansion tool 108. Also, as a result, the interior portion of the launcher 110 below the mandrel 104 is pressurized thereby causing the mandrel, mud motor 106, and the rotary expansion tool 108 breasurized thereby displaced upwardly relative to the launcher 110.

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The upward displacement of the mandrel 104, mud motor 106, and rotary expansion tool 108 then radially expands and plastically deforms at least the tubular section 110b and the tapered tubular section 110c of the launcher 110 and the expandable tubular member 112. In an exemplary embodiment, the tapered surface 104d of the expansion mandrel 104 provides the majority of the radial expansion and plastic deformation of the tapered tubular section 110c of the launcher 110 and the expandable tubular member 112. In an exemplary embodiment, the outside diameter of the rotary expansion tool 108 is adjustable and thereby permits the rotary expansion tool 108 to radially expand and plastically deform the expandable tubular member 112 into intimate contact with the walls of the borehole 114. As a result, the formation surrounding the expandable tubular member 112 may be compressed and, after the completion of the radial expansion and plastic deformation of the expandable-tubular member, held in compression. In an exemplary embodiment, during the operation of the apparatus 100, the expansion mandrel 104 applies radial forces to contiguous circumferential interior surfaces of the tubular launcher assembly 110 and/or the expandable tubular member 112, and the rotary expansion tool 108 applies radial forces to discrete noncontiguous interior surfaces of the tubular launcher assembly and/or the expandable tubular member.

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During the operation of the apparatus 100, in an exemplary embodiment, the expansion mandrel 104 provides a strain controlled radial expansion process, and the rotary expansion tool 108 provides a stress controlled radial expansion process. For example, the final inside diameter of the expandable tubular member 112 provided by operation of the expansion mandrel 104 is controlled by the shape and geometry of the expansion mandrel and should be constant. However, the final inside diameter of the expandable tubular member-provided by operation of the rotary expansion tool 108 may, or may not, be constant depending upon the shape of the wellbore 116. In particular, the amount of strain of the expandable tubular member 112 provided by the rotary expansion tool 108 is not controlled. Rather, the amount of stress applied to the expandable tubular member 112 by the rotary expansion tool 108 is controlled by controlling the compliance of the roller expansion elements 108a. Consequently, in an exemplary embodiment, the operation of the rotary expansion tool 108 will cause the outside diameter of the expandable tubular member 112 to engage and thereby match the inside diametrical shape of the wellbore 116. A strain controlled radial expansion process is typically capable of providing more radial expansion and plastic deformation

of a strain controlled expansion process with a stress controlled expansion process
engagement with an irregularly shaped wellbore 116. Consequently, the combination
expansion process is typically more capable of expanding a tubulat member into
than a stress controlled radial expansion process. However, a stress controlled radial

104. The rolary expansion foot is not rotated relative to the mandrel 104. 112 - In several alternative embodiments, during the operation of the apparatus 100, during the radial expansion and plastic deformation of the expandable tubular member - the tubular support member 102, mandrel 104, and/or mud motor 106 are also rotated In several alternative embodiments, during the operation of the apparatus 100, provides the benefits of both in one radial expansion process.

plastic deformation of the tubular member: injection of the fluidic material 120 during at least a portion of the radial expansion and relative to the tubular member of its in combination with, or in substitution for, the The an alternative embodiment, the expansion mandret 104 spulled upwardly

and the rotary expansion device 108 through the tubular launcher assembly 110 and/or that the resulting axial force applied to the cup seals pulls the expansion mandrel 104 expansion mandrel 104 within the expandable tubular member 112 is pressurized such is not fluid tight. As a result, the annulus defined between the cup seals 114 and the 104 and the tubular launcher assembly 1.10 and/or the expandable tubular member 1.12 In several exemplary embodiments, the interface between the expansion mandrel

the expandable tubular member (4) 2 and increases and a consistency of a second series of the consistency of the

In several alternative embodiments, a conventional hydro-forming device may be mandrel 104 and/or rotary expansion tool 108 may be reversed. In several alternative embodiments, the order and/or orientation of the expansion

In several alternative embodiments, the expansion mandrel 104 and/or the rotary substituted for, or used in addition to, the expansion mandrel 104.

Inc. may be substituted for, or used in combination with, the expansion mandrel 104. commercially available rotary expansion tools available from Weatherford International, disclosures of which are incorporated herein by reference, or any one of the as, for example, as described in U.S. 6,457,532 and/or WO 02/081863 AT, the In several alternative embodiments, a conventional rotary expansion tool such expansion tool 108 are adjustable in size.

implemented using the methods and/or apparatus disclosed one or more of the In several alternative embodiments, the exemplary embodiments of Fig. 1 are

following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791-03-02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02; filed on 2/10/2000, which claims priority from provisional application 60/119,611; filed on 2/11/99; (4) U.S. patent no 6,328,113; which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98; (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04. filed on 7/1/02, which claims priority from provisional application 60/183,546; filed on 2/18/00; (6) U.S. patent application serial no. 09/523,468; attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional 15 application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was = filed as patent application serial no. 09/512,895, attorney docket no. 25791-12.02, filed on 2/24/2000, which claims priority from provisional application 60/121.841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial prino≥ 09/51/1,941; attorney docket no. 25791.16.02, filed⇒on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557 640, which was filed as patent application serial no. 09/588,946, attorney docket no: 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998; filed on 6/7/99; (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number: 09/440,338; attorney docket number: 25791.9.02; filed on: 11/15/99, which claims priority from provisional application 60/108,558; filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which daims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593), attorney:docket:no: 25791:25.08, filed:on: 1/8/02; which:claims:priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on

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which claims priority from U.S. provisional patent application serial no: 60/270,007, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, application serialino. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, attorney docket no. 25791.48.06, which claims priority from provisional patent on 9/18/2000, (27)-U.S. patent application senal no. 10/406,648, filed on 3/31/03, 30 provisional patent application serial no. 60/233,638, attorney docket no. 25791.47; filed most vinoing emisls claims priority from filed on 1/22/03 attorney docket no. no. 25791.46, filed on 7/28/2000, (26) Batent application senal no. 10/322,947, claims priority from provisional patent application serial no. 60/221,645; attomey docket application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which 52 -60/221,443, attomey docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent no: 25791-45.07 which claims priority from provisional patent application serial no. (24)-U.S. patent application serial no 10/311,412, filed on 12/12/02, attomey docket - patent application senal no. 60/303,711, attorney docket no. 25791 44; filed on 7/6/01, -6/26/02, attomey docket no. 25791.44.02, which claims priority from U.S. provisional docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attomey patent application serial no: 60/165,228, attorney docket no: 25791.39, filed on 60/212,359, attorney docket no 25791.38, filed on 6/19/2000, (21) U.S. provisional no. 25791.38.07; which claims priority from provisional patent application serial no. (20) U.S. patent application senal no. 10/303,992, filed on 11/22/02, attomey docket application senal no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999 attorney docket no. 25791.37.02, which claims priority from provisional patent ,00/2/01 no balit ,809,678/60. on laines notiscition application 10/679,906, filed on 10/5/00. patent application senal no. 60/159,039, attorney docket no: 25/91:36, filed on -filed on 3/27/02 afformey docket no: 25791:36.03, which claims priority from provisional no. 25791.34, filed on 10/12/1999, (18) G.S. patent application serial no. 10/089,419, claims priority from provisional patent application serial no: 60/159,082, attorney docket application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as (16) U.S. provisional patent application serial no: 60/438,828, attorney docket no. application serial no: 60/154,047, attorney docket no. 25791:29, filed on 9/16/1999, attomey docket no 25791.27, filed on 11/1/1999, (15) U.S. provisional patent 4/30/02, which claims priority from provisional patent application serial no. 60/162,671,

attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001; (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, 5 attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452;303, filed on 3/5/03, attorney dockel no. 25791:53 (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as 10 a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791 03 02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed 20 as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02; filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application senal no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001; (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority

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attorney docket no. 25791.71:02, which claims priority from U.S. provisional patent 60/108,558;-filed on 11/16/98; (48) PCT application US 03/00609; filed on 1/9/03, number 25791.9.02, filed on 11/15/99, which claims priority from provisional application which was filed as U.S. Patent Application senal number 09/440,338, attorney docket on 10/3/2001, which is a continuation-in-part application of U.S. patent no: 6,328,113, U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed sattomey docket no 25791:70, filed on 12/10/01; which is a continuation application of . 60/105,555, filled on 11/10/98, (47) U.S. utility patent application serial no. 10/516,467, 25791.9.02, filed on 11/15/99, which daims priority from provisional application 25 as as U.S. Patent Application senal number 09/440,338, attorney docket number which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed spplication serial no. 09/969,922, attorney docket no. 25791,69; filed on 10/3/2001, = 60/343,674, attorney docket no. 25791-68, filed on 12/27/2001, (46) U.S. utility patent ** 25/91 68.02, which claims priority from 8.9 provisional patent application serial no. 20 9/10/2001; (45) PCT application US 02/39425; filed on 12/10/02; attorney docket no. patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on =60/317,985, attorney docket no 25791,67, filed on 9/6/2001, and U.S. provisional 25797.67.03; which claims priority from U.S. provisional patent application serial no. **3/1/99; (44) PCT application US 02/25727; filed for 8/14/02; attorney docket no. 15: 3/10/2000, which claims priority from provisional application 60/124,042, filed on U.S. patent application senal no. 09/523,468, attomey docket no 2579 text 1.02, filed on --- no.: 09/962,468, filed on 9/25/01, aftorney docket no.-- 25791-66, which is a divisional of - provisional application 60/124,042, filed on 3/1/199, (43) U.S. patent application senal morty from serior server no: 25791.11.02, filed on: 3/10/2000, which claims priority from 10. - 25791.65; which is a divisional of U.S. patent application senal no. 09/523,468; ** patent :: application :: serial - no :: 09/962, 467; #filed :: on : 9/25/01; | :attomey | docket | no claims, priority from provisional application 60/124,042, filed on 3/1/1/99, (42) U.S. ---serial no=09/523;468; attorney docket no-25793;414.02; filed on-3/10/2000, which 9/25/01; attorney docket no. 25791.64, which is a divisional of U.S. patent application 5 - 60/124,042, filed on 3/1/199, (41), U.S. patent application serial no. 09/962/471, filed on 25791.11.02; filed on 3/10/2000, which claims priority from provisional application divisional of U.S. patent application senal no. 09/523,468, attomey docket no. serial no. 09/962, 470, filed on 9/25/01, attomey docket no. 25791.63, which is a from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application

application serial no. 60/357,372, attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02; filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074;244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841; filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no.: 25791:12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 15 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895; attorney docket no. 25791.12.02; filed on 2/24/2000; which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial -no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80 filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application senal no 09/512,895, attorney docket no 25791:12.02; filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no 10/078,921, attorney docket no 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application

application senal no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) attomey docket no -- 25791.92.02, which claims priority from U.S. provisional patent 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, from U.S. provisional patent application serial no. 60/391,703, attorney docket no. US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority no. 60/383,917, attorney docket no. 25791.89; filed on 5/29/02, (65): PCT application no. 25791.89.02, which claims priority from U.S. provisional patent application serial filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attomey docket provisional patent application serial no. 60/339,013, attomey docket no. 25791,88, 25 filed on 11/12/02, afformey docket no. 25791.88.02, which claims priority from U.S. attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, which claims priority from U.S. provisional patent application senal no 60/338,996, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, 20 patent application senal no. 09/588,946, attomey docket no. 25791.17.02, filed on 10/1/02, which is a divisional of U.S. patent-number 6,557,640, which was filed as patent application senal no. 10/261,926; attorney docket no. 25791-86, filed on. . claims: priority from provisional application 60/121,841; filed on 2/26/99, (61) serial no 09/512,895, attomey docket no 25791,12.02, filed on 2/24/2000, which 15 is a divisional of U.S. patent number 6,568,471, which was filed as patent application application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which monty from provisional application 60/137,986 filed on 6/7/99, (60) gatent no 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims divisional of U.S. patent number 6,557,640, which was filed as patent application senal 10 serial no. 10/262,009, attomey docket no. 25791.84, filled on 10/1/02; which is a noissiliqgs frated 2:U (e3), e6/32/2 no ball (f.48,f.2.f/03 noissiliqqs lisnoisivoiq moit ...09/512,895, afformey docket no. 25791 12:02, filed on 2/24/2000, which claims priority O.S. patent number 6,568,471, which was filled as patent application senal no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of application 60/137,998, filed on 6/7/99, (58) U.S. patent application senal no. docket no. 25791.17.02, filed on 6/7/2000, which daims priority from provisional number 6,557;640, which was filed as patent application serial no. 09/588,946, attorney attomey docket no 25791.82, filed on 10/1/02, which is a divisional of U.S. patent 626, £32/0, ... on Ishez notisolidgs the set 3.U (53) , 99/2/2 no befit 1.54, 928,

PCT application US 03/06544; filed on 3/4/03, attorney docket no. 25791,93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791:94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95/02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 10 25791.95; filed on 3/13/02, (70) U.S. patent application serial no. 10/261;927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number = 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791-17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791:98, filed on 10/1/02, which is a divisional of U.S. patent number .6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946; attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application -60/137,998, filed on 6/7/99, (73) U.S. patent application serial no -10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney 25 docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791-101-02; which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101; filed on -4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no.: 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284

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no: 25791.128, filed on:9/20/02, (94) U.S. provisional patent application serial no. 9/20/02, (93) U.S. provisional patent application senal no. 60/412,187, attorney docket patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 60/423,363, attorney docket no. 25791.126, filed on 12/10/02, (92) U.S. provisional no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 30 priority from U.S. provisional patent application serial no. 60/407,442, attorney docket PCT/US03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims 60/412,544; attorney docket no: 25791.121; filed on 9/20/02, (90) PCT application no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 8/23/02; (88) U.S. provisional patent application serial no. 60/405,394, attorney docket 52 patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 12/7/98, (85) U.S. provisional patent application senal no. 60/412,177, attorney docket 12/3/1999, which claims priority from provisional application 60/111,293, filed on 50 Patent Application serial no. 09/454;139, attorney docket no. 25791-03.02, filed on a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial not 10/280,356, attorney docket not 25791,115, filed on 10/25/02, 25791-112, filed on 9/20/02; (83) 2.U S. provisional patent application senal no. U.S. provisional patent application serial no 60/412,487, attorney docket no application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) attorney docket no. 25791.111.02, which daims priority from U.S. provisional patent 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, from U.S. provisional patent application senal no. 60/398,061, attomey docket no. US 03/20694, filed on 7/1/03, attorney docket no. 25791-110.02; which claims priority no: 60/387,961, attorney docket no. 25791.108; filed on: 6/12/02, (80) PCT application no: 2579.1.108.02, which claims priority from: U.S. provisional patent application serial filed on 6/10/02; (79) PCT application US 03/18530, filed on 6/11/03, attorney docket provisional patent application serial no. 60/387,486; attorney docket no: 25791.107, filed on 5/5/03, attorney docket no. 25791.107.02; which claims priority from U.S. attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787,

60/412,371, attorney docket no. 2579fi129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorney docket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946; attorney docket no. 25791-17.02; filed on 6/7/2000, 5 which claims priority from provisional application 60/137,998; filed on 6/7/99; (96) U.S. patent application serial no: 10/624,842, attorney docket no... 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial 10 ==no: 60/431,184; attorney docket no: 25791.157; filed on 12/5/02; (98) U.S. provisional -patent application serial no.-60/448,526, attorney docket no. 25791.185, filed on 2/18/03 (99) U.S. provisional patent application serial no.::60/461,539, attorney docket no. 25791.186, filed on 4/9/03, (100) U.S. provisional patent application serial no. -- 60/462,750, attorney docket no. 25791.193, filed on 4/14/03, (101) U.S. provisional 15 patent application senal no 60/436,106, attorney docket no. 25791.200, filed on 12/23/02, (102) U.S. provisional patent application serial no. 60/442,942, attorney docket no. 25791:213, filed on 1/27/03; (103) U.S. provisional patent application serial no. 60/442,938, attorney docket no. 25791-225, filed on 1/27/03, (104) U.S. provisional patent application, serial no +60/418,687; attorney docket no. 25791-228, filed on 20 4/18/03, (105) U.S. provisional patent application serial no 60/454,896, attorney docket no. 25791.236, filed on 3/14/03, (106) U.S. provisional patent application serial no. 60/450,504, attorney docket no. 25791.238, filed on 2/26/03, (107) U.S. provisional patent application serial no. 60/451,152; attorney docket no. 25791.239, filed on 3/9/03, (108) U.S. provisional patent application serial no. 60/455,124, attorney docket no. 25 25791,241, filed on 3/17/03, (109) U.S. provisional patent application serial no. 60/453,678, attorney docket no. 25791.253, filed on 3/11/03, (110) U.S. patent application serial no 10/421 682, attorney docket no 25791 256, filed on 4/23/03, which is a continuation of U.S. patent application serial no. 09/523,468, attorney docket no: 25791.11:02, filed on 3/10/2000, which claims priority from provisional application 30 60/124,042, filed on 3/11/99, (111) U.S. provisional patent, application serial no---60/457,965, attorney docket no. 25791,260, filed on 3/27/03, (112) U.S. provisional patent application serial no. 60/455,718; attorney docket no. 25791,262, filed on 3/18/03, (113) U.S.: patent number 6,550,821, which was filed as patent application serial no. 09/811,734; filed on 3/19/01, (114) U.S. patent application serial no.

reference 斯雷特拉斯斯 人名格特 人名英格兰人姓氏克里特的变体 化乙二基甲基二甲基乙基乙基甲基 25 25791=40.02, filed on 3/15/04; the disclosures of which are incorporated herein by PCT patent application senal no. PCT/US04/ PCT/US04/ afformey docket no 25791.253.02, filed on 3/11/04, and (124) _qocket no: 25791,238.02, filled on 2/26/04; _ (123) PCT patent application settal no. 3/11/99, (122) PCT patent application senal no: PCT/USO4/ 20 == 3/10/2000, *which claims priority from provisional application 60/124,042, filed on patent application senal no 09/523,468; attorney docket no 25791 (1.1.02, rilled on attomey docket no. 25/21/25/14/4 wird being on 4/18/03; as a division of U.S. utility ,883,814/01-.on renas noisosiggs final by C.S. utility patent application senal no. 10/418,688, number 25.79.19.02; filed on 1117 5/99; which claims priority from provisional application 15 which was filed as U.S. Patent Application serial number 09/440,338, attorney docket 10/3/2001; which is a continuation in part application of U.S. patent no. 6,328,113, utility patent-application senal no: 09/969;922; attorney docket no. 25791:69; filed on stlomey docket no: 25791;292, filed on 7/14/03, which is a continuation-in-partiof U.S. 10 4/17/03, (119) U.S. provisional patent application serial no. 60/472,240, attorney docket Patent application senal no 60/463,586, attorney docket no 25791.277, filed on ** 60/461,038; attomey docket no 25791.273; filed on 4/7/03; (118) U.S. provisional 25791 272, filed on 4/8/03, (117) U.S. provisional patent application senal no-U.S. provisional patent application señal no 60/461,094, attorney docket no. application senal no. 60/459,776, attomey docket no. 25791-270, filed on 4/2/03, (116) provisional spplication; 60/131/106; filled ton 34/26/99; f(115); U.S. provisional patent attorney docket no=25791-23:02, filed on=4/26/2000, which claims priority from U.S. patent number 6,604,763, which was filed as application serial no 09/559,122, 10/436,467; attorney docket no 25791,268; filed on 5/12/03; which is a continuation of

has been described that includes a tubular support member defining a fubular member tubular expansion cone defining a second passage coupled to the tubular expansion cone defining a second passage coupled to the output shaft of the fluid driven motor. The first passage is operably coupled to the second passage, and the second passage, and the second passage, and the second passage is operably coupled to the ribid driven motor.

An apparatus for radially expanding and plastically deforming a tubular member

has been described that includes a first expansion device for controllably straining the tubular member; and a second expansion device coupled to the first expansion device for controllably stressing the tubular member. In an exemplary embodiment, the apparatus further includes a motor coupled to the first expansion device for rotating the second expansion device relative to the first expansion device.

A method of radially expanding and plastically deforming a tubular member has been described that includes controllably straining the tubular member, and then controllably stressing the tubular member.

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An apparatus for radially expanding and plastically deforming a tubular member has been described that includes means for controllably straining the tubular member, and means for controllably stressing the tubular member after controllably straining the tubular member.

An apparatus for radially expanding and plastically deforming a tubular member has been described that includes a first expansion device for radially expanding the tubular member, and a second expansion device coupled to the first expansion device for further radially expanding the tubular member. In an exemplary embodiment, the apparatus further includes a motor coupled to the first expansion device for rotating the second expansion device relative to the first expansion device.

A method of radially expanding and plastically deforming a tubular member has been described that includes radially expanding a portion of the tubular member, and then further radially expanding the portion of the tubular member. In an exemplary embodiment, radially expanding the portion of the tubular member includes applying forces to a continuous circumferential portion of the interior surface of the tubular member. In an exemplary embodiment, further radially expanding the portion of the tubular member includes applying forces to one or more discrete portions of the interior surface of the tubular member.

A system for radially expanding and plastically deforming a tubular member has been described that includes means for radially expanding a portion of the tubular member, and means for then further radially expanding the portion of the tubular member. In an exemplary embodiment, the means for radially expanding the portion of the tubular member includes means for applying forces to a continuous circumferential portion of the interior surface of the tubular member. In an exemplary embodiment, the means for further radially expanding the portion of the tubular member includes means for applying forces to one or more discrete portions of the interior surface of the tubular

member

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An apparatus for radially expanding and plastically deforming a tubular member and means for controllably straining the tubular member; so controllably straining the tubular member.

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing a pipeline, or a structural support. Furthermore, the teachings of the present disclosure may incorporate one or more features or operational aspects of conventional hydro-forming tools.

Although illustrative embodiments of the invention have been shown and abscribed, a wide range of modification, changes and substitution is contemplated in a manner consistent may be employed without a corresponding use of the other features. Accordingly, it is may be employed without a corresponding use of the other features. Accordingly, it is with the scope of the invention.

CLAIMS:

- 4. A method of radially expanding and plastically deforming a tubular member, comprising:
- radially expanding a portion of the tubular member; and _______ then further radially expanding the portion of the tubular member;

wherein radially expanding the portion of the tubular member comprises applying forces to a continuous circumferential portion of the interior surface of the tubular member; and

wherein further radially expanding the portion of the tubular member comprises applying forces to one or more discrete portions of the interior surface of the tubular member;

wherein the method further comprises:

radially expanding another portion of the tubular member; and

- wherein the step of then further radially expanding the portion of the tubular member and the step of radially expanding the another portion of the tubular member are simultaneously performed progressively along substantially the entire length of the tubular member to be radially expanded and plastically deformed.
- 20 2 The method of claim:1-wherein the tubular member is expanded and plastically deformed with a rotary expansion tool.

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3. The method of claim 1 wherein the tubular member is a pipeline.

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- 25 4. The method of claim 1 wherein the tubular member comprises a structural support.
 - 5: The method of claim 1 wherein the tubular member is expanding with a hydroforming device.

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CLAIMS OF PARENT CASE

An apparatus for radially expanding and plastically deforming a tubular member, the tubular member. 30 means for controllably stressing the tubular member after controllably straining means for controllably straining the tubular member; and :gnishqmoo An apparatus for radially expanding and plastically deforming a tubular member, then controllably stressing the tubular member. 52 controllably straining the tubular member; and :6uisudmoo A method of radially expanding and plastically deforming a fubular member; expansion device. Special Control State (Special Special 20 expansion device for rotating the second expansion device relative to the first The apparatus of claim 2, further comprising a motor coupled to the first Ξ. stressing the tubular member. s second expansion device coupled to the first expansion device for controllably 🐃 afitist expansion device for controllably straining the fubular member; and An apparatus for radially expanding and plastically deforming a tubular member, will a care to as the notom wherein the second passage is operably coupled to the inlet of the fluid driven wherein the first passage is operably coupled to the second passage; 10 ' = - '' s rotary:expansion device coupled to the output-shaft of the fluid driven motor; satinid-driven motor/coupled to the tubular expansion cone comprising an inlety The state of the s nedmem hodque a inbular expansion cone defining a second passage coupled to the lubular a tubular support member defining a first passage; :comprising: Air apparatus for radially expanding and plastically deforming a tubular member, What is claimed is:

a second expansion device coupled to the first expansion device for further

a first expansion device for radially expanding the tubular member; and

radially expanding the tubular member.

- 7. The apparatus of claim 6; further comprising a motor coupled to the first expansion device for rotating the second expansion device relative to the first expansion device.
- 5 8. A method of radially expanding and plastically deforming a tubular member, comprising:

radially expanding a portion of the tubular member, and then further radially expanding the portion of the tubular member.

9. The method of claim 8, wherein radially expanding the portion of the tubular member comprises:

applying forces to a continuous circumferential portion of the interior surface of the tubular member.

- 10. The method of claim 8, wherein further radially expanding the portion of the tubular member comprises:
- applying forces to one or more discrete portions of the interior surface of the tubular member.
 - A system for radially expanding and plastically deforming a tubular member, comprising:

means for radially expanding a portion of the tubular member; and means for then further radially expanding the portion of the tubular member.

12. The system of claim 11, wherein means for radially expanding the portion of the tubular member comprises:

means for applying forces to a continuous circumferential portion of the interior surface of the tubular member.

25. 13. The system of claim 11, wherein means for further radially expanding the portion of the tubular member comprises:

means for applying forces to one or more discrete portions of the interior surface of the tubular member.

14. A method of radially expanding and plastically deforming a tubular member;30. comprising:

controllably stressing the tubular member; and

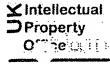
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then controllably straining the tubular member.

15: An apparatus for radially expanding and plastically deforming a tubular member, comprising:

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means for controllably stressing the tubular member after controllably stressing



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Application No:

GB0715478.4.

Examiner:

Dr Lyndon Ellis

Claims scarched:

1-5

Date of search:

3 September 2007

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Relevant to claims	Identity of document and passage or figure of particular relevance
1+3:	EP1505251 A3 (Metcalfe) Whole document, noting a swage and roller expanders
1-3	US3785193 A (Clark) Whole document, noting swage S and expander E
	to claims

Categories:

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X	Document indicating lack of novelty or inventive	Α	Document indicating technological background and/or state
	step		of the art.
Y	Document indicating lack of inventive step if	P	Document published on or after the declared priority date but
1	combined with one or more other documents of		before the filing date of this invention
	same cutegory .		£.
&	Member of the same patent family	1	Patent document published on or after, but with priority date.
ļ .			earlier than, the filing date of this application.

Field of Search:

Search of GB; EP, WO & US patent documents classified in the following areas of the UKCX:

Worldwide search of patent documents classified in the following areas of the IPC.

B21D; E21B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
E21B	0043/10	01/01/2006